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# Nitrate Poisoning

Michelle Arnold
*University of Kentucky*, michelle.arnold@uky.edu

Cynthia Gaskill
*University of Kentucky*, cynthia.gaskill@uky.edu

Jeff Lehmkuhler
*University of Kentucky*, jeff.lehmkuhler@uky.edu

S. Ray Smith
*University of Kentucky*, raysmith1@uky.edu

**COOPERATIVE EXTENSION SERVICE**
**UNIVERSITY OF KENTUCKY COLLEGE OF AGRICULTURE, FOOD AND ENVIRONMENT, LEXINGTON, KY, 40546**

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# Forage-Related Cattle Disorders
# Nitrate Poisoning

*Michelle Arnold and Cynthia Gaskill, Veterinary Diagnostic Laboratory;*
*Jeff Lehmkuhler, Department of Animal and Food Sciences; and Ray Smith, Department of Plant and Soil Sciences*

## Sources of Nitrates

Nitrates are present in all plants, but normally their concentrations are not excessive. Under normal growing conditions, nitrate from the soil is absorbed by the roots of forage plants, and is supplied to the upper portions of the plant (primarily leaves) where it is converted into plant protein. However, adverse environmental conditions (such as drought), sudden weather changes (cool, cloudy weather), leaf damage (due to hail, frost, or herbicides), or heavy fertilization with nitrogen, can cause plants to develop and retain potentially dangerous levels of nitrate. The lower stalks and stems at the base of the plant are the site of accumulation. Grains, seeds and leaves do not accumulate significant amounts. Nitrate levels will remain high until there is new leaf growth. Plants with high stem-to-leaf ratios are more likely to cause nitrate intoxication. Levels of nitrate will remain high until there is new leaf growth, increasing photosynthesis that provides the necessary energy to utilize the excess nitrate. Hay will remain a hazard because toxicity is unchanged by drying, but the nitrate concentrations in ensiled forage crops may be reduced by up to 60 percent with proper fermentation and microbial degradation.

Drought-stressed sorghum and/or corn are the source of most of the forage-related cases of nitrate poisoning in Kentucky, but wheat, sudangrass, rye, pearl millet, soybeans, beets, *Brassica* spp. (rape, kale, turnips, swedes) and oats can also accumulate nitrates. Common weeds that are nitrate accumulators include ragweed, pigweed, thistle, bindweed, dock, jimsonweed, and johnsongrass. These lists are not complete, but these weeds and forages cause the most problems within the state.

Nitrates in water sources may also poison livestock. Surface water or water from shallow wells may contain nitrates, especially if there is run-off from fertilized land contaminating the water. Both water and forage should be analyzed to ensure that total nitrate does not exceed toxic levels.

Nitrate poisoning in ruminants may also result from consumption of nitrate fertilizer. Cattle that gain access to stored nitrate fertilizers, especially when deprived of salt, may consume toxic quantities very quickly.

## Cause of Poisoning

When consumed more rapidly than they can be converted in the rumen to protein, nitrates enter the bloodstream as nitrite, which combines with hemoglobin in red blood cells to produce methemoglobin, a form incapable of transporting oxygen. Death occurs as a result of asphyxiation as methemoglobin levels approach 80 percent.

Nitrate and nitrite poisoning can occur in all animals but cattle are considered most susceptible because of the rapid conversion of nitrate to the more toxic nitrite form by rumen microorganisms.

Horses are much less sensitive to nitrate than are cattle or other ruminants, and can tolerate much higher concentrations of nitrate, but exact threshold values have not been established. Horses are extremely sensitive to nitrite, so any preformed nitrite in forages can pose a significant risk. Consult with a veterinary clinical toxicologist for interpretation of nitrate/nitrite concentrations in horse feeds.

Sheep and goats are less susceptible than cattle to nitrate toxicity and camelids are rarely affected.

## Signs of Poisoning

The first indication of nitrate toxicity may be the discovery of one or more dead animals while others may be exhibiting clinical signs. These first signs of nitrate poisoning in an animal include weakness; rapid, labored breathing; rapid, weak heart beat; staggering; muscle tremors; and recumbency (inability to stand). Affected animals typically show signs of poisoning within a few hours after consumption of a toxic dose of nitrates. Examination of the mucous membranes, especially the vaginal mucous membranes, may reveal a brownish discoloration that occurs well before other clinical signs. Chocolate colored blood and a brownish cast to all tissues are hallmark signs of nitrate poisoning. Most deaths occur within the first six to eight hours after onset of clinical signs and largely depend on the quantity and rate of absorption of nitrite and the amount of stress or exercise the animal is forced to do. After death, nitrate concentration can be measured in the eye fluid and is a reliable indicator of poisoning. Pregnant cows that survive toxicity will likely abort three to seven days following recovery from nitrate poisoning.

## Treatment

Animals showing signs of nitrate poisoning should be removed from the source of toxicity and a veterinarian should be contacted immediately. Animals severely deprived of oxygen are subject to sudden death so stress associated with handling must be minimized. Administration of a two-percent solution of methylene blue intravenously by the veterinarian will aid in converting methemoglobin back to hemoglobin. Mineral oil or other emollients may be given to protect the lining of the digestive tract.

Vinegar given orally via stomach tube will help prevent further nitrate reduction in the rumen.

## Prevention

Several management strategies are available to reduce the risk of nitrate poisoning.

- Nitrate fertilizer should be stored where cattle do not have access to it and accidental spills should be cleaned up promptly.
- Avoid grazing warm season grasses fertilized with high amounts of nitrogen when growth ceases due to drought, cold damage, hail, or herbicide exposure. Warm season grass stands that have received multiple sources of nitrogen (such as nitrogen fertilizer, manure, previous legume crops) can occasionally show elevated nitrate levels without environmental stress. When in doubt, take the time to send samples for nitrate testing before introducing cattle to the pasture.
- Cool season grasses and small grain pastures that have been heavily fertilized with nitrogen may be high in nitrates during early spring when cool, overcast days retard growth. Test before grazing.
- Corn forage should be properly ensiled at least 3 weeks and tested for nitrates before feeding. Do not green chop forages suspected to be high in nitrates.
- All suspected forages including silage and hay should be tested for nitrate levels. Instructions are provided in this publication-see "Nitrate Testing." A field test is also available to give a quick indication if the forage is potentially dangerous. If the test strip reacts, a forage sample should be sent to a laboratory for an accurate analysis of nitrate and a feeding recommendation. Consult your county Extension agent for agriculture for information concerning sampling, sample preparation, field test, and location of a testing laboratory.
- Forage with high nitrate levels can be mixed with forage known to be low in nitrate to reduce the risk from feeding.
- Feeding low nitrate forage or hay before turning cattle on to high nitrate forages will reduce the amount of nitrate consumed. Splitting grazing times will also allow nitrates to be utilized properly by the rumen microflora.
- Cattle have the ability to increase their tolerance to nitrates in their diet with time. A period of adaptation of at least a week is recommended. To aid in increasing this tolerance, the diet should be sufficient in vitamin A and trace minerals.
- A gradual increase in the total energy content of the ration enhances metabolism in the rumen and helps cattle tolerate higher nitrate levels in their diet. This may be in the form of a high carbohydrate feed such as corn that aids microbes in the conversion of nitrates to protein.
- Delay harvest of high nitrate forages until nitrate levels are safe. If not feasible to delay harvest, raise the cutter bar to 18 inches to avoid the base of plants.
- Propionibacterium products such as Bova-Pro® are available in bolus or powder form that are reported to reduce nitrate and nitrite levels in the rumen by approximately 40 percent. These products must be established in the rumen for at least 10 days before allowing cattle to consume high nitrate feedstuffs.

## Nitrate Testing

Contact the laboratory you intend to use or your local county agent for specific instructions, but some general guidelines are listed below.

### Taking Samples

Proper sample collection is crucial for proper interpretation of results. The sample should represent what the animals will be eating, so collect the entire part of the plant that will be fed. Collect a number of smaller samples to form a large representative composite sample. If different regions of a field were treated differently, then separate composite samples should be submitted for each different region. Different cuttings, batches, or fields should be sampled separately, and submitted as separate samples.

Preferably at least a pound of total composite sample should be submitted. More sample is better than too little, so when in doubt, collect more. Be sure to mark each bag legibly with forage/sample type and identification information.

**Dry forage (hay, bedding)**—Use a hay probe to take core samples. Randomly select 10 or more bales that are representative of a cutting/batch. Take one or more core samples per bale, and mix all the cores to make one large composite sample.

**Silage, balage, haylage**—Use a hay probe to take core samples if possible. Randomly select 10 or more bales that are representative of a cutting/batch. Take one or more core samples per bale, and mix all the cores to make one large composite sample. Reseal the hole created in the wrap with tape after sampling. For bagged silage, select at least 10 areas to sample that are representative. If core sampling is not possible, unload some silage material and collect large handfuls from 10 or more different locations. Mix to form a large composite sample.

**Corn stalks**—Cut the stalks at the anticipated harvest level and submit the entire part of the stalk that will be fed. Collect stalks from several areas of the field; 5 or more stalks are recommended. Stalks can be cut or folded prior to shipping. Alternatively, if the corn stalks are going to be chopped, you can collect representative samples from the fresh chop. Or, if shipping volume is an issue, only the bottom halves of the stalks could be submitted, but remember that the result will be higher than the actual overall average nitrate concentration for the entire plant.

**Pasture grasses**—Collect handfuls of forage from 10-20 different areas in the field. Cut the grass at the anticipated harvest or grazing height and submit the whole part of the plant that will be ingested. Mix thoroughly to make one large composite sample.

### Storage and Shipment

Moist samples (such as fresh green grasses, silage) should be placed in plastic bags and immediately put in a cooler on ice or ice packs. These samples should be kept chilled or frozen until shipment, and should be shipped with ice packs. Dry samples such as relatively dry corn stalks and hay should be placed in paper bags and kept at room temperature until shipped; ice packs are not needed for shipment of dryer samples. Regardless, samples should be shipped as soon as

possible after collection. Samples should be shipped overnight, or delivered directly to the laboratory. Note: Storage of moist plant samples in plastic bags at room temperature will result in bacterial growth and reduction of nitrate to nitrite, resulting in inaccurate nitrate results.

## Testing Laboratories

The two veterinary diagnostic laboratories in Kentucky that perform nitrate testing on forages are the University of Kentucky Veterinary Diagnostic Laboratory and the Murray State University Breathitt Veterinary Center. Both are accredited by American Association of Veterinary Laboratory Diagnosticians.

Several commercial laboratories, such as Dairy One Forage Laboratory, conduct the nitrate testing as well.

**University of Kentucky Veterinary Diagnostic Laboratory (UKVDL)**
Carrier (UPS/FedEx) Shipping Address:
1490 Bull Lea Rd
Lexington, KY 40511
Contact for nitrate questions:
Dr. Cynthia Gaskill
(859) 257-7912

**Murray State University Breathitt Veterinary Center**
715 North Drive
Hopkinsville, KY 42241-2000
Phone: (270) 886-3959
Fax: (270) 886-4295
Contact for nitrate questions:
Dr. Ramesh Gupta
(270) 886-3959

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## Interpreting Results

All sources of dietary nitrate, including feeds, forages, supplements, and water should be taken into consideration when determining total dietary nitrate concentration (Table 1). Representative sampling is crucial for proper interpretation of results. Also, nitrite, a breakdown product of nitrate that can be found in forages, is much more toxic than nitrate, and much lower levels of nitrite can cause poisoning and death.

Be aware that nitrate levels can be reported a variety of ways and the method of expression can differ between laboratories. Nitrate can be reported as nitrate ($NO_3$), nitrate-nitrogen ($NO_3$-N), or potassium nitrate ($KNO_3$). These numbers are *not* equivalent, as they represent different chemical structures. Make sure the feeding guidelines used for a particular result match the type of analysis performed. To convert between the different methods of reporting, use the conversions in Table 2.

Forage nitrate results can also be reported using a variety of units. The most common units of measurement are parts per million (ppm) or percentage. Results are usually reported on a dry matter basis. To convert from ppm to percentage, move the decimal point four places to the left (eg, 5,000 ppm = 0.50 percent).

**Table 1.** Nitrate levels and feeding options for cattle.

| Total dietary nitrate ($NO_3$) in dry matter | Feeding guidelines |
|---|---|
| < 5,000 ppm (0.5%) | Generally safe for cattle. Be cautious with pregnant and young animals when nitrate concentrations approach 5,000 ppm and dilute with other feeds |
| >5,000 but <10,000 ppm (>0.5% but <1%) | Dilute with other feeds and introduce slowly. Consider options to reduce nitrate in fresh forage (ensiling, delayed harvest, other). Limit to a maximum of 50% of the total dry matter in pregnant animals |
| >10,000 ppm (1%) | Very dangerous; can cause acute nitrate poisoning and death in cattle. Do not feed. |

**Table 2.** Conversion options for different reporting methods.

| Method of expression | Chemical designation | To convert to $NO_3$, multiply by | To convert to $NO_3$-N, multiply by | To convert to $KNO_3$, multiply by |
|---|---|---|---|---|
| Nitrate | $NO_3$ | 1.00 | 0.23 | 1.63 |
| Nitrate-nitrogen | $NO_3$-N | 4.40 | 1.00 | 7.20 |
| Potassium nitrate | $KNO_3$ | 0.61 | 0.14 | 1.00 |

# Conclusion

Few plants normally contain high nitrate levels, since under normal growing conditions the nitrates are converted to protein as quickly as they are absorbed from the roots. However, under certain conditions such as high nitrogen fertilization, drought or abrupt changes in weather, plants can develop dangerously high nitrate levels. The main problem with excess nitrates is that they are converted in the rumen to nitrites that are absorbed in the bloodstream and ultimately prevent the red blood cells from carrying life-giving oxygen. Death or abortion may result as a consequence of nitrate intoxication. Care must be taken to recognize possible toxic forages and manage them appropriately to avoid animal loss. The laboratory you intend to use or your local county agent can provide specific instructions for nitrate testing.


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